PSEUDOMONAS DISEASES ON CUCURBITS IN WESTERN WASHINGTON

Introduction

Cucurbits are well-suited for the maritime climate in western Washington and are considered high value specialty crops. For example, the most recent USDA NASS census data for pumpkins grown in Washington show that 398,000 cwt were produced with a value of $11,844,000 (USDA NASS 2019) in 2018. However, cucurbits are susceptible to a number of bacterial pathogens that can reduce fruit quality. One such group of bacterial pathogens is *Pseudomonas syringae*. Bacteria are microscopic, single-celled organisms, and *Pseudomonas syringae* are tiny rod-shaped organisms that are approximately 0.8 by 1–2 µM (Keinath et al. 2017). Within this species are a number of pathovars, or strains, that cause similar symptoms on cucurbits.

The Pathogens

Pseudomonas syringae pv. *lachrymans* (*Psl*) and *Ps*. *syringae* pv. *syringae* (*Pss*) are plant pathogenic bacteria that cause disease problems on cucurbit crops. *Psl* is well established in the Pacific Northwest, and elsewhere. Optimal temperatures for *P. syringae* are between 74°F and 91°F (23°C and 33°C), and excess moisture is the significant factor for promoting bacterial growth (Hirano and Upper 1990), which make western Washington's coastal climates favorable to *P. syringae* epidemics. The warm summer temperatures, high rainfall, and humidity also are favorable for production of cucumber, pumpkin, and squash.

Pss also can be found in the western Washington region and is a known pathogen on lilac, cherry, and maple, causing stem blights, cankers, and dieback. However, although *Pss* has been reported on watermelon in Georgia (Dutta et al. 2016), it is unclear whether it is also a significant pathogen on PNW cucurbits. Recently, a strain that is distinct from *Psl* and closely related to *Pss*, based on genetic information and symptoms, was collected from pumpkin foliage and fruits in western Washington and has been identified as a strain of *P. syringae* pv. *aptata* (*Psa*) (Tymon et al., forthcoming).

The Symptoms

For *Psl*, symptoms on leaves occur early in the season. Initial infections result in water soaking, or small, tan to brown lesions, which expand when environmental conditions are conducive. Chlorosis (yellowing of plant tissue) surrounding the lesion is evident when infection occurs on susceptible cultivars. The lesions are typically angular in shape due to restricted expansion by large leaf veins (Figure 1). As the leaves dry and become necrotic (dead), the lesions turn brown to grey-brown to tan. The dead tissue can drop out of the leaf, giving it a ragged appearance (Figure 2). Lesions can also occur on stems. On fruit, symptoms include water soaking and tan-brown lesions that are circular in shape. These infection sites allow for secondary fungal and bacterial invaders to colonize the fruit, leading to rot (Keinath et al. 2017).

Leaf lesions caused by *Pss* are tan, with dark margins, and are generally circular. Symptoms on fruit have not been described. Leaf lesions caused by *Psa* cause tan-brown to black lesions on susceptible hosts, surrounded by bright yellow chlorosis, which can often be observed along the margins of leaves (Figure 3A). The bright yellow chlorosis is typically noticeable on leaves early in the season, before flowering. This symptom may be an indicator of future fruit infection should wet and cool conditions occur throughout the remainder of the growing season. On fruit, lesions have a "bulls-eye" appearance and may raise to form warts (Figure 3B). Warts may crack at the margin, compromising the protective epidermis and cuticle, leaving soft fruit tissues below vulnerable to secondary infections. Cavities can develop due to these infections followed by significant fruit rot (Figure 3C and Figure 3D). Fruit that are infected by *P. syringae* strains have reduced storability, especially in facilities with high humidity.

Figure 1. Angular, water soaked lesions caused by *P. syringae* pv. *lachrymans* on a cucumber leaf. Photo courtesy of the Bayer Group.

Figure 2. Necrotic tissue and ragged appearance of a cucumber plant infected by *P. syringae* pv. *lachrymans* on a cucumber leaf. Photo courtesy of the Bayer Group.

Figure 3. Leaf lesions surrounded by chlorosis on pumpkin 'Cinnamon Girl' leaves (A) and bull's-eye lesions (B). Warts (C) on fruit caused by a recently isolated, unidentified *P. syringae*, and secondary fruit rot (D) on *P. syringae* infected fruit. Photo A, B, and D courtesy of L.S. Tymon, and photo C courtesy of P. Morgan.

The Disease Cycle

P. syringae bacteria are seedborne and have the ability to associate with the seed coat, which is why symptoms are observed early in the season when plants start to grow. High humidity and warm temperatures favor disease outbreaks (Young et al. 1977). Under these conditions, bacterial populations can increase exponentially. Levels of bacteria in seed can be low, making them difficult to detect and can result in seedling infections , but field epidemics can occur due to the rapid multiplication rate of these bacteria (Balaž et al. 2014) once in the field. If crops sustain high levels of disease due to early *P. syringae* infections, financial losses to cucurbit growers can be significant.

When seed is infested, these *P. syringae* pathogens can infest cotyledons, which often remain symptomless when they emerge from infested seed. The bacteria then are washed from leaves onto flowers where it can infect developing placental tissues and susceptible developing fruit (Keinath et al. 2017). Otherwise, the bacterium spreads to other leaves, plants, and fruits by rain splash, overhead irrigation, insects, workers, and machinery where hosts are infected through stomata (pores in tissues that allow for gas exchange) or wounds (Keinath et al. 2017; Pscheidt and Ocamb 2019). While *P. syringae* pv. *lachrymans* overwinters in the soil on intact host debris, where it can survive for over 90 weeks when soils are irrigated (Kritzman and Zutra 1983), the survivorship of *Pss* on cucurbit residues is not known.

Management

Management options of bacterial pathogens, in general, are limited, but can include cultural practices, such as minimizing leaf wetness, securing pathogen-free seed, planting resistant cultivars, and rotating crops so that cucurbits are not planted for at least two years. At this time, resistant cultivars to *P. syringae* diseases on cucurbits are only available in cucumber. However, pumpkin and squash cultivars with waxy, thick rinds, such

'Orange Cutie' buttercup squash and 'Kabocha' squash, have been shown to have less disease than pumpkin cultivars with thin rinds, such as 'Cinnamon Girl,' when inoculated with *Psa* (Tymon and Inglis 2017). Hot water seed treatments are a pre-plant management tactic since *P. syringae* are seedborne pathogens. However, treatments with hot water alone are not effective. Treatments should include either calcium proprionate or acidic cupric acetate (Table 2) (Pscheidt and Ocamb 2019). Applications of Actigard 50WG or copper fungicide products (see WSU PICOL website for a current listing of registered products in Washington; current registrations are shown in Table 1) at the onset of symptom development provide some chemical management options for plants in the field. However, copper products may be phytotoxic on hosts and build-up in the soil with continued use. The application intervals and reentry-intervals may differ among production systems, so it is critical to review label instructions prior to product applications.

Table 1. Cultural tactics for *Pseudomonas syringae* strains infecting cucurbits (Pscheidt and Ocamb 2019).

Cultural controls	
Use clean, pathogen-free seed	
Crop rotation	
Resistant cultivars (only cucumber)	
Pickling cultivars	**Slicing cultivars**
Regal	Victory
Royal	Slice Nice
Pioneer	Raider
Frontier	Quest
Express	Encore
Calypso	Dasher II
Cross Country	Bel Aire

Table 2. Chemical tactics for controlling *Pseudomonas syringae* strains infecting cucurbits (Pscheidt and Ocamb 2019).

Chemical controls	**Rate**
Actigard 50 WG	0.5 oz to 1.0 oz/acre
Fixed copper products[y]	
Cueva	0.2–2.0 gal/acre
Cuprofix Ultra	1.2–2.0 lb/acre
Liqui-Cop	2–3 tsp/gal water
ManKoCide	2–3 lb/acre
Nu Cop 50 WP	1.3–3 lb/acre
Hot water seed treatments[z]	
Hot water + calcium proprionate	4.4 oz/gal water
Hot water +cupric acetate	6.7 oz/gal water

[y] Copper products may cause phytotoxicity on some plants.

[z] Hot water seed treatments alone are not shown to be effective.

References

Balaž, J., R. Iličić, S. Maširević, D. Jošić, and S. Kojić. 2014. First Report of *Pseudomonas syringae* pv. *syringae* Causing Bacterial Leaf Spots of Oil Pumpkin (*Cucurbita pepo*) in Serbia. *Journal of General Plant Pathology* 81: 331–50.

Dutta, B., R. Gitaitis, J. Driver, and S. Smith. 2016. First Report of Bacterial Leaf Spot on Watermelon Caused by *Pseudomonas syringae* pv. *syringae* in Georgia. *Plant Disease* 100(2): 518.

Hirano, S.S., and C.D. Upper. 1990. Population Biology and Epidemiology of *Pseudomonas syringae*. *Annual Review of Phytopathology* 28: 155–77.

Keinath, A.P., W.M. Wintermantel, and T.A. Zitter. 2017. Compendium of Cucurbit Diseases and Pests. *American Phytopathological Society* (APS Press).

Kritzman, G., and D. Zutra. 1983. Survival of *Pseudomonas syringae* pv. *lachrymans* in Soil, Plant Debris, and the Rhizosphere of Non-Host Plants. *Phytoparasitica* 11: 99.

Pscheidt, J.W., and C.M. Ocamb, eds. 2019. Cucumber (Cucumis sativus)-Angular Leaf Spot, in *Pacific Northwest Plant Disease Management Handbook*. Corvallis, OR: Oregon State University.

Tymon, L., K. Bophela, S.J. Martins, L. Ramos-Sepúlveda, D.A. Inglis, T. Coutinho, and C.T. Bull. Forthcoming. Fruit Warts and Leafspots of Cucurbits Caused by Diverse Strains within *Pseudomonas syringae* pv. *aptata*.

Tymon, L., and D. Inglis. 2017. Identification and Pathogenicity of *Pseudomonas syringae* Genomospecies 1 Phylogroup 2b Causing Leaf Spots and Fruit Warts on Cucurbits in Western Washington, US. *Journal of Plant Pathology* 99.

USDA NASS (United States Department of Agriculture National Agricultural Statistics Service). 2019. Economics, Statistics and Market Information System.

Young, J., R. Luketina, and A. Marshall. 1977. The Effects on Temperature on Growth In Vitro of *Pseudomonas syringae* and *Xanthomonas pruni*. *Journal of Applied Bacteriology* 42: 345–54.

By
Lydia Tymon, Associate in Research and Plant Pathologist, Department of Plant Pathology, Washington State University;
Debra Inglis, Professor Emerita and Extension Plant Pathologist, Department of Plant Pathology, Washington State University, Northwestern Washington Research and Extension Center, Mount Vernon, WA

WSU PEER REVIEWED

FS335E